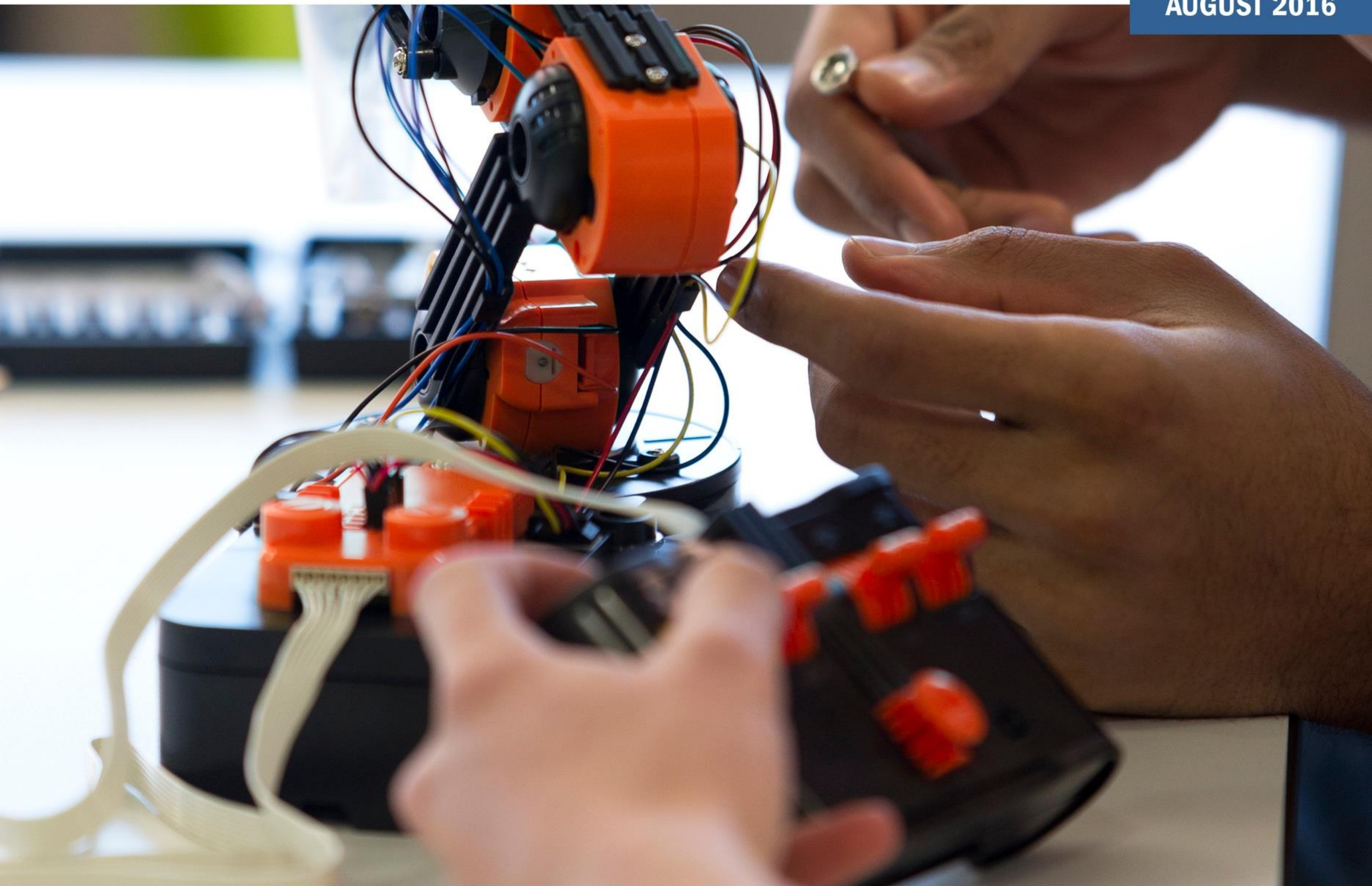
MIDWEST Comprehensive Center at American Institutes for Research

Wisconsin Department of Public Instruction

FROM CAREER PIPELINE TO STEM LITERACY FOR ALL

Exploring Evolving Notions of STEM

AUGUST 2016



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Introduction

As an acronym, the term "STEM" is commonly understood to refer to the four distinct disciplines of science, technology, engineering, and mathematics. Within the STEM education community, current notions of STEM are evolving and may be taking on a broader, more integrated and inclusive meaning and purpose. To best inform the actions and recommendations of state departments of education and state-affiliated groups engaged in STEM teaching and learning, the Wisconsin Department of Public Instruction (DPI) expressed an interest in examining emerging trends in how STEM education is defined and conceptualized within the STEM education community, and to explore the implications of these trends for policy, professional supports, and the practices of Wisconsin educators.

This report explores evolving notions of STEM and the implications of these trends for STEM efforts within the state of Wisconsin. This report is organized around four guiding questions:

1. How is STEM currently defined and understood within the STEM education community?
2. How is STEM currently defined and addressed within K–12 education standards, including *A Framework for K–12 Science Education*, the Next Generation Science Standards, the Common Core State Standards for Mathematics, and the Common Career Technical Core Standards?
3. How is the term "STEM" currently defined and envisioned by states in the Midwest STEM Network?
4. How do prevailing trends in notions of STEM align with or differ from the STEM definitions as outlined by Wisconsin DPI and STEM Wisconsin?

Methods

To answer these guiding questions, staff from the Midwest Comprehensive Center gathered and reviewed evidence from the following sources to identify present trends in how STEM is defined and conceptualized within the education community[1]:

- Document reviews, including federal legislation, K–12 education standards, reports and research reviews, and other articles and reports sponsored by national organizations from STEM fields
- Website scans of state and state-affiliated STEM groups participating in the Midwest STEM network, including sites sponsored by government agencies, and national professional organizations (see Appendix A for a list of websites reviewed)
- Reviews of the DPI STEM webpage as well as the STEM Wisconsin working group webpage and related documents
- Key informant interviews with seven individuals, including members of the Midwest STEM network, industry representatives, and other leaders from within the STEM education community (see Appendix B for a list of key informants and their affiliations)

[1] The STEM education community is defined as professionals and organizations engaged in educational initiatives focused on STEM and/or the separate fields of science, technology, engineering, and mathematics.

Findings

Key findings from the document and website reviews and interviews are outlined in this section and are organized by the four guiding questions.

Guiding Question 1: How is STEM currently defined and understood within the STEM education community?

To identify past and emerging trends related to definitions and conceptualizations of STEM, we began by conducting document reviews using a range of government and other national organization sources (see the list of sources in Appendix C). The evidence collected from these initial sources suggest that notions of STEM are currently evolving, and that emerging notions of STEM reflect a broader, more integrated and inclusive meaning and purpose than more traditional definitions that narrowly define STEM as four distinct disciplines. Key findings from this set of reviews are discussed next.

Background

Evidence has suggested that the origin of the term "STEM" is rooted in U.S. interests to protect and enhance our national military strength and global economic competitiveness (Gonzalez & Kuenzi, 2012; National Defense Education Act, 1958). The STEM Primer released by the Congressional Research Service in 2012 (Gonzalez & Kuenzi, 2012) outlined key STEM legislation in U.S. history. The Primer traced U.S. legislation related to STEM as far back as the Morrill Act of 1862 (National Archives and Records Administration, n.d.). However, the authors suggested that modern views of STEM are likely related to two key pieces of legislation that occurred in the 1950s: the creation of the National Science Foundation (National Science Foundation Act of 1950) and the National Defense Education Act of 1958. According to Gonzalez and Kuenzi (2012, p. 31), the NSF was established in 1950—in part—to "develop and encourage the pursuit of a national policy for basic research and education in the sciences." As Gonzalez and Kuenzi (2012) explained, the creation of the NSF was soon followed by the National Defense Education Act of 1958. According to the report's authors, the National Defense Education Act of 1958 was passed in response to the Soviet Union's launch of Sputnik with the aim of increasing the numbers of students who entered STEM fields. Based on their extensive review, the authors concluded, "A primary rationale behind federal STEM education policies relies on their perceived impact on the U.S. S&E [science and engineering] workforce—and through it, on U.S. economic competitiveness and national security" (Gonzalez & Kuenzi, 2012, p. 15).

Current national interest and investments in STEM education remain high; economic competitiveness continues to serve as a major rationale for STEM funding. For example, the federal fiscal year budget for 2016 includes more than $3 billion in STEM education funding shared across 15 federal agencies (Office of Science and Technology Policy, 2015). A review of STEM legislation issued in the past 10 years suggests that STEM funding continues to focus on making the United States economically competitive, primarily through building career pathways that help create a pipeline of highly qualified scientists, engineers, and mathematicians entering those professions (Gonzalez & Kuenzi, 2012; Government Accountability Office, 2006; STEM Education Act, 2015; America COMPETES Act, 2007). One likely reason for cross-agency

STEM-focused priorities is that the set of knowledge, skills, and abilities associated with learning and practicing STEM disciplines is now in demand across nearly all job sectors and occupations (Carnevale, Smith, & Melton, 2011; Rothwell, 2013).

Since the term "STEM" was officially coined in 2000 (replacing an emerging acronym at the time: SMET[2] [Koonce, Zhou, Anderson, Hening, & Conley, 2011; Patton, 2013]), the acronym has most commonly been used to refer to the four disciplines of science, technology, engineering, and mathematics indicated in the acronym. Yet, even among and across federal and state agencies, there are inconsistencies in which fields of study are included. For example, the NSF includes social sciences in its definition of STEM, and recent U.S. legislation officially expanded the definition of STEM to include computer science (Institute of Education Sciences, U.S. Department of Education, and the NSF, 2013; NSF & National Science Board, 2015; STEM Education Act, 2015; U.S. Department of Education, n.d.).

Emerging Notions of STEM

Although the term "STEM" retains associations with its original roots aimed at creating a strong career pipeline for a STEM-specific workforce, evidence from numerous sources, including document and website reviews, suggests that present notions of STEM encompass a broader, more integrated and inclusive meaning and purpose (Blosveeren & Voytek, 2015; Gonzalez & Kuenzi, 2012; Honey, Pearson, & Schweingruber, 2014; Moon & Singer, 2012; NSF & National Science Board, 2015). From our reviews and interviews, we identified evidence for four themes related to current conceptualizations of STEM:

1. STEM as a broad, inclusive term encompassing many fields and competencies
2. STEM as an integrated, interdisciplinary field
3. STEM as an educational approach
4. STEM as an essential 21st century competency area valuable for all students

The four emerging trends, outlined above, were initially identified through document reviews representing a range of sources. To further examine the extent to which these emerging trends were reflected within the STEM education community, the Midwest Comprehensive Center team conducted scans of 13 websites hosted by government agencies and national STEM education groups. For each website visited, the team looked for and documented, as available, any formal definition of STEM, the specific academic disciplines referenced as part of STEM, the types of skills and competencies associated with STEM learning, and references to STEM as an educational approach. The team also collected data from these websites on each organization's purpose and intended audience within the K–12 STEM education community. In addition to website scans, interviews were conducted with seven individuals, including members of the Midwest STEM network, industry representatives, and other leaders from within the STEM education community.

[2] SMET included the fields of science, mathematics, engineering, and technology.

National STEM Education Websites Reviewed

- U.S. Department of Education
- National Science Foundation (NSF)
- Association for Career and Technical Education (ACTE)
- Computer Science Teachers Association (CSTA)
- Education Commission of the States
- International Technology and Engineering Educators Association (ITEEA)
- National Council of Teachers of Mathematics (NCTM)
- National Science Teachers Association (NSTA)
- STEM Education Coalition
- STEMx
- International Technology Education Association (ITEA)
- The International Society for Technology in Education (ISTE)
- SkillsUSA

Table A1 gives a summary of relevant information collected and reviewed from website scans.

It is important to note that several of the websites reviewed (five of the 13) did not explicitly include the term "STEM" or offer formal definitions of STEM, and some of these organizations did not refer to more than one of the disciplines included within the STEM acronym (i.e., only referred to technology or mathematics).

1. STEM as a broad, inclusive term encompassing many fields and competencies

Although the four main disciplines of science, technology, engineering, and mathematics are explicitly represented in the acronym, our reviews indicate that STEM is now seen by many in the field as an overarching, broad, and inclusive term that encompasses dozens of disciplines and subdisciplines. For instance, of the 294 occupations and majors tracked by ACT (ACT, 2014), 93 of these are considered to be related to STEM. In the *National Science and Engineering Indicators* (National Science Board, 2014), 65 subdisciplines are included. Our scan of websites hosted by national STEM-affiliated organizations found references to multiple fields outside of the traditional STEM disciplines, including computer science, social sciences, agricultural science, and manufacturing. Recent U.S. legislation has officially expanded the definition to include computer science as an explicit part of STEM (STEM Education Act, 2015; U.S. Department of Education, n.d.).

Responses from key informants offered supporting evidence for this trend. For example, to Jillian Steffek, a senior principal engineer at Oshkosh Corporation, manufacturing is assumed to fall within STEM. Steve Triplett, program director of STEM partnerships for ACT, noted that ACT includes four categories under their definition of STEM majors and occupations. They include science, computer science and mathematics, medical and health, and engineering and technology. Kim Wetzel, foundation director consultant of the Bemis Company Foundation, explained:

> We don't break it down—but do believe that technology includes IT, and the 5 subdisciplines within IT are all part of STEM.

As the term "STEM" expands to include many more disciplines and subdisciplines within and across less traditionally labeled STEM fields, there are some in the STEM education community who believe that the STEM acronym should also change. Jeff Weld, executive director for the Iowa Governor's STEM Advisory Council, shared his thoughts on this debate within the STEM field:

> STEM is a broad umbrella term….Those representing some of the subfields have concern that they are not being sufficiently recognized within the STEM world. Advocates for those subtopics lobby rigorously for their subtopics to be recognized. For example, those in health and medicine are asking whether STEM should have an extra "M" to reflect medicine. Those in computer science are wondering about adding a "C" to the term "STEM" to indicate computers.

Other respondents shared hesitations with the new trend toward understanding STEM as encompassing multiple disciplines and indicated a resistance to expanded notions of what constitutes STEM education and any modification to the acronym. For example, Ms. Wetzel shared:

> What I have seen from our foundation is curriculum creep. Applicants to our foundation are now including reading, music, or the arts into their STEM proposals—STEAM.
>
> I can see some of their points are valid. It does not exist entirely on its own. So, we are always being pushed to think about very broad definitions of STEM. But, the down side is that it becomes grayer as you reach further.

2. STEM as an integrated, interdisciplinary field

Another emerging trend observed is the notion that the term "STEM" and approaches to STEM education are integrated and interdisciplinary in nature. In our scan of 13 websites hosted by national STEM-affiliated organizations, we found that the most prevalent trend observed was the notion of STEM and STEM education as interdisciplinary. Nine websites referenced the integration or interconnection between STEM disciplines or indicated that the integration of the specific subjects that fall under the STEM acronym is essential in STEM teaching and learning. For example, the International Technology and Engineering Educators Association (ITEEA) website offered the following explanation: "Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments and academic levels" (ITEEA, n.d., para. 4). The STEM Education Coalition website declared that STEM education is interdisciplinary, stating, "STEM fields are closely related and build on each other. For example math provides the foundation for physics—and physics in turn, for engineering" (Vilorio, 2014, p. 3). The National Science Teachers Association refers to STEM as interdisciplinary and that STEM teaching and learning is applied across discipline-specific contexts and integrates subjects together, particularly technology/engineering within science and mathematics. STEMx refers to STEM education as "transdisciplinary" (Ashida, 2014, para. 3).

SkillsUSA, a partnership of students, educators, and industry professionals focused on developing a skilled workforce, argues that the integration of disciplines is essential to a definition of STEM:

> The magic of CTE is the definition of STEM not just Science or Technology, Engineering or Math but the integration of two or more of these topics in the context that students are passionate about. Without the combination of two or more of the STEM components you are not teaching STEM. (SkillsUSA, n.d., para. 4)

At the federal agency level, the NSF hosts an Office of Integrative Activities (OIA), which "incubates initiatives that capitalize on new interdisciplinary scientific and engineering concepts." OIA administers research programs that combine STEM disciplines and promote integrated STEM education (NSF, n.d., para. 2).

Responses from key informants offered further evidence for this observed trend toward integration in STEM education. For example, Ms. Wetzel shared:

> STEM is about "problem solving towards innovation." The four areas are not stand alone pillars, but pillars with cross over into other STEM and non-STEM disciplines. STEM is more about the integration than about the separate disciplines.

Dr. Weld remarked:

> Any responsible STEM educator would see STEM as more than the separate subdisciplines**.** STEM is interdisciplinary in nature, in its approach, curriculum, and philosophy….. I see the interdisciplinary nature as the hallmark of STEM.

While some sources reviewed and respondents interviewed indicate an interest in STEM being considered its own "metadiscipline," several respondents did not concur with this direction. For example, Dr. Michael Lach, director of STEM education and strategic initiatives at the University of Chicago, explained:

> While in many parts of academia the boundaries between disciplines are increasingly becoming blurred, at the K–12 level STEM is an umbrella term for the four disciplines, STEM is generally not its own discipline.

Jeremy Eltz, assistant director of college and career readiness at the Indiana Department of Education, shared:

> Some educators see STEM as its own discipline, offer "STEM Time."
>
> To me there is an interrelationship, but it can be separate or integrated. I would characterize STEM as interdisciplinary, but not a metadiscipline or its own discipline.
>
> I wouldn't want to see STEM pulled out. STEM should be natural and organic, infused, not siloed on its own.

Recognizing and responding to the growing trend toward integration in STEM, the National Academy of Engineering and National Research Council (NRC) formed a Committee on Integrated STEM Education and conducted a research review to examine the evidence for taking a more integrated approach to STEM education (Honey et al., 2014). As explained in the introduction to the report *STEM Integration in K–12 Education: Status, Prospects and an Agenda for Research* (Honey et al., 2014, p. viii), the committee members reviewed relevant research and examined a sample of programs identified as engaging in integrated STEM education to identify approaches to STEM integration and assess evidence for its benefits for students. The report authors admitted that they were not able to achieve a consensus on a clear definition for the meaning of "Integrated STEM." The authors noted in the introduction to their "Descriptive Framework for Integrated STEM Education" that integrated STEM refers to the "connections between and among STEM subjects" (Honey et al., 2014, p. 31). The authors further clarified that

> Between and among refers to connection between any two STEM subjects (e.g. most commonly math and science)…. Seen this way, integrated STEM education occupies a multidimensional space in the larger K–12 education landscape: Rather than a single, well-defined experience, it involves a range of experiences with some degree of connection. The experiences may occur in one or several class periods, or throughout a curriculum; they may be reflected in the organization of a single course, or an entire school, or they may be presented in after-or-out of school activity. (Honey et al., 2014, p. 31)

The authors concluded that the trend toward integration in STEM is showing promise—especially for underrepresented groups. At the same time, the authors conveyed caution toward an exclusive focus on STEM integration, arguing, "students need to be competent with discipline-specific representations and able to translate between them, exhibit what some scholars refer to as 'representational fluency'" (Honey et al., 2014, p. 144).

Despite the prevalence of references to STEM education as integrated and interdisciplinary or transdisciplinary, it is important to note that we did not find a common, official definition of what integrated STEM teaching and learning means. However, most sources that offered clarification on the meaning of integration in STEM defined it as simply the connection between two or more STEM subjects. For example, in their article, "Considerations for Teaching Integrated STEM Education" (Stohlmann, Moore, & Roehrig, 2012), the authors explained that, "Integrated STEM activities allow teachers to focus on big ideas that are connected or interrelated between subjects" (p. 30). In addition, "integrated STEM education can involve multiple classes and teachers and does not have to always involve all four disciplines of STEM" (p. 30).

In her article "STEM—Beyond the Acronym" (Vasquez, 2015), author JoAnne Vasquez noted that "STEM education is an approach to learning that removes the traditional barriers separating the four disciplines and integrates them into real-world, rigorous, relevant learning experiences for students" (p. 11). However, the author noted, "STEM…doesn't necessarily have to incorporate all four of the STEM disciplines every time…" (p. 12). Vasquez offered a more nuanced explanation of STEM integration, characterizing graduating levels of integration as falling along an inclined plane. Vasquez's continuum began with singular, separate disciplinary learning on the low end, moving along to multidisciplinary where distinct disciplinary learning is linked together through a common theme, to interdisciplinary, whereby "concepts and skills from two or more disciplines are tightly linked so as to deepen knowledge and skills" (p. 12) to transdisciplinary, characterized as "undertaking real-world problems or projects, students apply knowledge and skills from two or more disciplines…" (p. 12).

3. STEM as an educational approach

In addition to the term "STEM" taking on an expanded and more integrated meaning, for some STEM is also viewed as a specific pedagogical approach or philosophy. We found that five of the 13 websites hosted by national, STEM-affiliated organizations explicitly referred to certain pedagogical approaches as integral to STEM education. For example, the Education Commission of the States includes problem-based and applied learning experiences in its definition of STEM education. The ITEEA defines an integrated approach to STEM education as "the application of technology/engineering design based pedagogical approaches." And, STEMx refers to integrated STEM as "a transdisciplinary approach which may include problem-based, design projects and other experiential methods."

Responses from key informants offered supporting evidence for this trend. For example, Mr. Eltz stated:

> I see STEM as an approach to education, a way of going back to student-driven classrooms that feature exploration, projects and inquiry. A STEM approach to education could be done in social studies, English class, or it could be about doing technology within music class.

Similarly, Dr. Weld shared:

> STEM was initially about the four disciplines, but there has been tremendous morphing going on. The term "STEM" has moved towards being a curricular approach, a line of thought, a philosophy. We are seeing an amorphous line of thinking where STEM now embodies innovation, creation, invention, collaboration, and problem solving…including new terms and contortions such as—STEMify, STEMtastic, and STEMrageous.

4. STEM as an essential 21st century competency area valuable for all students

A final trend noted in our reviews was a shift in beliefs about the purposes of STEM education. Traditional views focused on exposing students to STEM in order to build a strong career pipeline aimed at expanding the STEM-specific workforce. In contrast, emerging trends suggest a focus on STEM literacy as an essential 21st century competency necessary for student success in any profession. For example, in a recent companion document to the *National Science and Engineering Indicators* (National Science Board, 2014), the NSF argued that in today's world, STEM is for "all Americans" (2015, p. 2). This report provided statistics to show that approximately 20% of all U.S. jobs at all levels currently require STEM skills to perform. The authors concluded that the national aim should be to prepare all students to become "STEM capable" as a means for best preparing them for success in the 21st century workplace, as well as ensuring our national competiveness. The term "STEM capable" is defined as encompassing both STEM discipline-specific and non-STEM knowledge and skills, such as problem solving, critical thinking, and collaboration. In addition, rather than STEM being viewed as an educational priority only for Grades 9–12, the NSF declares that STEM is valuable across the entire PreK–12 continuum (NSF, 2015, p. 14).

Responses from key informants offered supporting evidence for this trend. For example, Cathy Stagmer, global community relations manager for Joy Global, shared:

> The engineering design process teaches students how to work through problems and come up with solutions. That skill, in general, carries over to any profession. In the Project Lead the Way classes I've sat in, having to keep a journal and keep track of everything teaches organizational skills and provides structure. That transfers over to other disciplines.

Dr. Lach explained:

> If you live in a world that is full of engineering and technology, students need to become facile and fluent in that world. Exposure to STEM and the disciplines allows them to gain that comfort. There is a jobs piece to STEM, but that is secondary to enabling students to be prepared to navigate in a world that is full of science, technology, engineering, and mathematics.

Mr. Triplett remarked:

> Everyone needs some fundamental competence in all STEM areas. Just to function effectively in our 21st century society you need a baseline in STEM.

Mr. Weld explained:

> STEM is for all students—and is good for society: most kids might not end up in STEM fields, but every kid will benefit from a grounding in problem solving, logic, creativity, invention, and the wonderful soft skills that are the benefit of STEM.

Mr. Eltz shared:

> The skills you develop through STEM provide success for any field you want to go in… At the same time, if we increase the numbers prepared for STEM, we will increase the numbers of people going into STEM careers. I want students to have those options, because they are not getting enough of them.

While overall emerging trends are moving toward a more integrated, expanded, and inclusive view of STEM, not everyone agrees wholeheartedly with this new direction. Some from the STEM field are concerned that emphasizing total inclusiveness in STEM education risks losing some of the value of STEM's initial intent (i.e., to build student competency and capacity specifically in specific core disciplines and to prepare, fill, and diversify the STEM workforce).

For example, Ms. Wetzel shared:

> STEM studies are good for all students because they foster critical thinking and problem solving. At the same time, there is a distinct interest in building the STEM pipeline, and attracting females and minorities into that pipeline.

Dr. Lach shared:

> There are lots of definitions for STEM, and lots of people with differing views of what that means and what it should mean. There are some people who think STEM means more than the sum of its parts**.** My view is driven by the accountability and organizational realities of K-12 schools and generally is that the content knowledge and skills in mathematics and science should be a priority, that considerable amounts of engineering are included in new science standards, and technology is pretty pervasive, but that the main pillars of STEM for schools should remain as science and mathematics.

In addition, the results of website scans suggest that national organizations representing the STEM education community embrace both traditional and emerging trends. For example, four websites reflected three of the four emerging trends, six websites reflected two of the emerging trends, and three reflected just one of the four emerging trends. This variability suggests that not all national organizations fully embrace emerging trends.

Guiding Question 2: How is the term "STEM" currently defined and addressed within K–12 education standards, including: *A Framework for K–12 Science Education*, the Next Generation Science Standards, the Common Core State Standards for Mathematics, and the Common Career Technical Core Standards?

To answer our second guiding question, an explicit review was conducted of four key sources: *A Framework for K–12 Science Education* (NRC, 2012; subsequently referred to as NRC framework); the Next Generation Science Standards (NGSS Lead State Partners, 2013; subsequently referred to as NGSS); the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010); and the Common Career Technical Core Standards (NASDCTEC, 2012). We reviewed these sources with a focus on identifying references to, and definitions of, STEM and to document any evidence that would support or refute emerging trends related to STEM as found in other sources. Our findings suggest that although the Next Generation Science Standards (NGSS Lead State Partners, 2013) and the Common Core State Standards for Mathematics do not explicitly reference STEM, an emphasis on the integration between the disciplines within these standards was evident in both primary and secondary sources. The term "STEM" is most explicitly referenced in the Common Career Technical Core Standards.

Science Standards

The NRC framework and NGSS, which are explicitly built on the NRC's framework, do not explicitly define STEM. However, both the framework's structure and explanatory language in the framework and NGSS continuously emphasize the value and importance of the integration of concepts and practices across the science, engineering, mathematics, and technology disciplines to enhance student learning in science (NRC, 2012; NGSS Lead State Partners, 2013).

For example, in the introduction to the NRC framework, the authors explained:

> Engineering and technology are featured alongside the physical sciences, life sciences, and earth and space sciences for two critical reasons: to reflect the importance of understanding the human-built world and to recognize the value of better integrating the teaching and learning of science, engineering, and technology. (NRC, 2012, p. 8)

The authors further noted that

> The framework is motivated in part by a growing national consensus around the need for greater coherence—that is, a sense of unity—in K–12 science education. (NRC, 2012, p. 10)

Within the NRC framework and NGSS, there are eight scientific and engineering practices. These practices serve as one of the three core dimensions that comprise the science education standards. As explained within the NRC framework and NGSS, these practices are not to be implemented in isolation; rather, they are to be interwoven with science learning across all core subjects and for all crosscutting concepts.

Despite the absence of explicit references to STEM in the NRC framework (NRC, 2012) and NGSS (NGSS Lead State Partners, 2013), there is evidence that the authors of the NRC framework and new standards are promoting a more integrated approach to STEM education and an emphasis on STEM education for all students, not just students aspiring to a STEM career. First, Honey et al. (2014) described the NGSS as providing "more and deeper connections among STEM subjects." Moon and Rundell (2012) explicitly examined STEM as reflected in the NRC framework and NGSS. They concluded that these new science standards focus on the integration of knowledge and practices across disciplines, encapsulating a new vision of STEM. In referring to the STEM trends evident in the new K–12 framework (NRC, 2012), the authors stated the following: "The K–12 Framework effectively turns attention away from a content specific definition of STEM to a more epistemic one—the sources, strategies, or practices from which science and, by extension, STEM knowledge comes and, in turn, is shared" (Moon & Singer, 2012, p. 1).

Mathematics Standards

The Common Core State Standards in mathematics do not reference the term "STEM" (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). The mathematics standards also do not explicitly refer to the integration of mathematics with the other STEM disciplines such as technology, engineering, and science; however, the standards do include a set of mathematical practices that are aligned to the scientific practices standards in the NGSS (NGSS Lead State Partners, 2013). Appendix L of the NGSS includes the crosswalk between the scientific practice standards and the Common Core State Standards for Mathematics to highlight this alignment (NGSS Lead State Partners, 2013). Following this trend, the National Science Teachers Association (NSTA) launched a campaign titled "STEM Starts Here." On this webpage, NSTA offers a diagram to illustrate the alignment of practice standards for mathematics, science, and English language arts (National Science Teachers Association, 2015).

Career and Technical Standards

The Common Career Technical Core Standards are divided into 16 Career Clusters, which are then divided into more specific Career Pathways with a specific set of standards. The way in which STEM is referenced and defined across the different subsets of the Common Career Technical Core Standards varies. For example, the standards for the STEM career clusters explicitly defines STEM as comprising the disciplines of "science, technology, engineering, and mathematics" (NASDCTEC, 2012, p. 20). The Science & Mathematics Career Pathway and the

Engineering & Technology Career Pathway more clearly allude to STEM as an integrated set of disciplines. For example, one Science & Mathematics pathway standard reads, "Apply science and mathematics to provide results, answers, and algorithms for engineering and technological activities" (NASDCTEC, 2012, p. 20). The standard for this particular pathway also describes STEM skills as including additional cognitive skills, such as critical thinking, analysis, data interpretation, and using the design process (NASDCTEC, 2012, p. 20). The standards also include a list of Career Ready Practices, which are not STEM-exclusive and apply across career clusters and pathways (NASDCTEC, 2012, pp. 2–3). These include personal competencies such as responsibility, communication, conscientiousness, creativity, innovation, critical thinking, integrity, productivity, and collaboration (NASDCTEC, 2012, pp. 2–3).

Guiding Question 3: How is the term "STEM" currently defined and envisioned by states in the Midwest STEM Network?

To answer our third guiding question, we worked in partnership with DPI to select 12 state or state-affiliated STEM groups that participated in the 2015 Midwest STEM Forum. Website scans were conducted for each of these groups to identify and document references to STEM, including how each group defined and described the purposes of STEM education.

The results of our website scans suggest that Midwest STEM organizations hold a range of perspectives on the meaning and purposes for STEM education. Although the vast majority (10) of the 12 state-affiliated organizations included on their website definitions, references, and/or stated purposes for STEM that reflected at least one (or more) of the four emerging STEM trends,[3] the extent to which these emerging trends were emphasized by organizations varied. For example, half of the organizations' websites only reflected one of the four emerging trends. Among these six websites, the most common trend observed were references to STEM as encompassing many disciplines, subdisciplines, and STEM-related competencies, such as critical thinking and problem solving. Several (four of the 12) state-affiliated organizations emphasized more traditional notions of STEM (i.e., STEM as a strategy to fuel the career pipeline and foster economic prosperity), and two of these four organizations did not reflect any of the emerging trends—emphasizing that the primary aim of STEM is to prepare students for STEM careers.

Four of the 12 organizations emphasized emerging STEM trends more strongly. For example, the Indiana STEM Resource Network includes critical thinking and problem solving as key STEM related competencies and promotes "STEM literacy for all students." The Iowa Governor's STEM Advisory Council reflects many of the emerging trends. Their website offers the following definition of STEM:

> An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering and mathematics in contexts that make connections between school, community, work and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. (Tsupros, Kohler, & Hallinen, 2009)

[3] As noted on page 3, the four emerging STEM trends are as follows: (1) STEM as a broad inclusive term encompassing many fields and competencies, (2) STEM as an integrated, interdisciplinary field, (3) STEM as an educational approach, and (4) STEM as an essential 21st century competency area valuable for all students.

The North Dakota Department of Public Instruction offers its definition of STEM as follows:

> Integrative STEM education refers to technological/engineering design-based learning approaches that intentionally integrate the concepts and practices of science and/or mathematics education with the concepts and practices of technology and/or engineering education. Integrative STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc. (North Dakota Department of Public Instruction, 2015, p. 2)

Please refer to Table A3 for a summary of STEM trends noted in website scans.

Guiding Question 4: How do prevailing trends in notions of STEM align with or differ from the STEM definitions as outlined by Wisconsin DPI and STEM Wisconsin?

For this last guiding question, two Wisconsin STEM-related webpages were reviewed: the STEM Wisconsin webpage and the DPI STEM webpage.

An analysis of the STEM Wisconsin webpage (Wisconsin Department of Public Instruction, n.d.) and a 2014 STEM Education Leadership Summit Executive Summary (STEM Wisconsin, 2014) suggests that STEM Wisconsin retains both a traditional focus on STEM as a key economic driver as well as embracing two of the four emerging trends—STEM education as interdisciplinary and STEM literacy as a competency that all students need to develop.

The DPI STEM webpage (STEM Wisconsin Leadership Committee, , n.d.) indicates that the Wisconsin DPI’s framing of STEM education is strongly consistent with all four emerging trends. The DPI STEM definition offered on the website primarily focuses on emerging notions of STEM. The website also includes one reference to the traditional purposes of STEM (i.e., that it is key to local and national economic health). In particular, the DPI STEM definition includes the following:

- STEM is a *metadiscipline*—used in multiple disciplines, problems, and contexts.
- STEM is a subject that should be approached in cross-disciplinary manner by educators.
- STEM is a mind-set.
- STEM literacy is a goal for all students.
- STEM is a philosophy of or an approach to problem solving that is more than the sum of its parts.
- STEM is a form of logical thinking grounded in an understanding of science, technology, engineering, and mathematics.
- STEM is more than a jobs program.
- STEM is valuable to the economy, both local and national.

The DPI defining characteristics most closely aligned with emerging views of STEM include the following:

- STEM is an integrated, interdisciplinary field.
- STEM includes an expanded set of competencies.
- STEM is more than a jobs program and should be a subject for all students.

The Wisconsin STEM definition also includes defining characteristics that generally reflect the intent of emerging trends but may not be as explicitly aligned with the characterizations, associations, and definitions of STEM that appear in other sources reviewed for this report, such as:

- STEM is a mind-set.
- STEM is a quantitative, collaborative, innovative, and logical analysis rooted in a solid understanding of science, technology, engineering, and mathematics.
- STEM is a philosophy of or an approach to problem solving that is more than the sum of its parts.[4]

Summary

The Wisconsin DPI requested assistance in understanding emerging trends related to notions of STEM, and an examination of the extent to which their state's STEM work reflects these emerging trends. This report reflects findings based on a review of documents, education standards, scans of national and state STEM organization websites, and a comparative analysis of Wisconsin STEM websites in light of emerging trends. The results suggest the following:

- Notions of STEM are currently evolving to reflect a more integrated and inclusive meaning and purpose.
- Evolving notions of STEM education have not been consistently articulated within the STEM education community, leaving room for varying interpretations.
- Emerging trends have not been fully embraced within the STEM education community, and some members indicate reservations or resistance to some of these changing notions.
- The notions of STEM reflected in the DPI website closely align with emerging views of STEM within the STEM education community.

[4] This characteristic aligns somewhat with the definition of integrative STEM that appears on the International Technology and Engineering Educators Association website, http://www.iteea.org/About.aspx.

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Appendix A. Website Scans

The Midwest Comprehensive Center team conducted scans of 13 websites hosted by government agencies and national STEM education groups. For each website visited, the team looked for and documented, as available, any formal definition of STEM, the specific academic disciplines referenced as part of STEM, the types of skills and competencies associated with STEM learning, and references to STEM as an educational approach. The team also collected data from these websites on each organization's purpose and intended audience within the K–12 STEM education community. Table A1 shows the results of STEM website scans across the federal government and national organizations. Table A2 shows data obtained from website scans across state agencies. Table A3 shows the grade spans, organizational affiliation, and the extent to which content related to defining characteristics of STEM that appears on websites for state-affiliated STEM organizations reflects traditional and emerging notions of STEM.

Table A1. Federal Government and National Organizations STEM Website Scans

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Government Agencies			
U.S. Department of Education	http://www.ed.gov/sites/default/files/stem-overview.pdf	The U.S. Department of Education oversees national education policy and research.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other: Page 2 of the STEM overview describes the importance of hands-on learning: "Together, these programs will…promote STEM education experiences that prioritize hands-on learning to increase student engagement, interest, and achievement in the STEM fields."
National Science Foundation (NSF)	▪ Disciplines: http://www.nsf.gov/funding/index.jsp#areas ▪ K–12 Funding Opportunities: http://www.nsf.gov/funding/education.jsp?fund_type=4 ▪ General information: http://www.nsf.gov/about/	NSF funds a broad range of science research. NSF grants include K–12 teaching fellowships.	▪ Academic disciplines included: • Biological sciences • Computer and information science plus computer engineering • Engineering • Geosciences • Mathematical and physical sciences • Social, behavioral, and economic sciences ▪ Other: NSF has an Office of Integrative Activities, which "incubates initiatives that capitalize on new interdisciplinary scientific and engineering concepts."

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
National Organization Websites			
Association for Career and Technical Education (ACTE)	STEM issue brief: http://ow.ly/VlJZw	ACTE promotes career and technical education (CTE) to prepare students for the workforce.	▪ Academic disciplines included: ACTE identifies 16 career clusters, which are academic disciplines within career and technical education. Of those, six are considered to be STEM intensive: • Agriculture, food, and natural resources • Health science • Information technology • Manufacturing • Science, technology, engineering, and mathematics • Transportation, distribution, and logistics ▪ Other: According to the issue brief, "CTE courses, through the thoughtful integration of STEM concepts, can help all students become more STEM literate and increase the chances that students consider STEM-related careers" (see pp. 4–5).
Computer Science Teachers Association (CSTA)	CSTA computer science standards: http://www.csta.acm.org/Curriculum/sub/CurrFiles/CSTA_K-12_CSS.pdf	CSTA consists of 16,000 K–12 computer science educators and information technology (IT) professionals.	▪ Academic disciplines included (see p. 6 for definitions of each): • Educational technology • IT • Computer science ▪ Other competencies include: • "A National Academy study published in 1999 defines IT fluency as something more comprehensive than IT literacy. Whereas IT literacy is the capability to use today's technology in one's own field, the notion of IT fluency adds the capability to independently learn and use new technology as it evolves throughout one's professional lifetime." • "Computational thinking is an approach to solving problems in a way that can be implemented with a computer. It involves the use of concepts, such as abstraction, recursion, and iteration, to process and analyze data, and to create real and virtual artifacts."

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Education Commission of the States	http://www.ecs.org/clearinghouse/91/79/9179.pdf	The Education Commission of the States consists of governors, state legislators, and education professionals. Members work together to compile and share information about state education issues.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other competencies included: • Problem-based, applied learning • Real-world learning experiences for teachers, which strengthen understanding and improve instruction ▪ Other: • This brief is from February 2011, and, at the time, the Commission noted the following: "Many 'STEM' education efforts often address only math and science…in practice the T—technology—often relates to computer technology, not technology education" (p. 4). • "Some argue that the development of model K–12 engineering standards is not feasible or desirable. Nonetheless, some states are making efforts to provide students—particularly in the late elementary and secondary grades—with meaningful opportunities to engage in engineering and pre-engineering learning experiences, and are establishing technology education programs informed by the Standards for Technological Literacy, developed by the International Technology Education Association" (p. 4).

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
International Technology and Engineering Educators Association (ITEEA)	http://www.iteea.org/About.aspx	ITEEA consists of more than 35,000 engineering and technology teachers across all grade levels.	▪ Academic disciplines Included: • Science • Technology • Engineering • Mathematics ▪ Other competencies included: • Integrative STEM education: The ITEEA website offers a definition of integrated STEM-adapted from a report authored by Wells and Ernst (2012). Integrative STEM Education is operationally defined as "the application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education through the content and practices of technology/engineering education. Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels."
National Council of Teachers of Mathematics (NCTM)	http://www.nctm.org/About/At-a-Glance/Statement-of-Beliefs/	NCTM has 80,000 members in the United States and Canada. NCTM is a co-chair organization of the STEM Education Coalition.	▪ Academic disciplines included: • Number skills • Algebra • Geometry • Measurement • Statistics ▪ Other competencies included: • Formal reasoning • Mathematical proofs ▪ Other: The Statement of Beliefs mentions technology as a tool for learning mathematics: The widespread impact of technology on nearly every aspect of our lives requires changes in the content and nature of school mathematics programs. In keeping with these changes, students should be able to use calculators and computers to investigate mathematical concepts and increase their mathematical understanding.

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
National Science Teachers Association (NSTA)	http://www.nsta.org/publications/news/story.aspx?id=59305	NSTA consists of more than 55,000 science educators, administrators, scientists, and industry professionals.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other facets identified within the definition of STEM: • NSTA recognizes that STEM definition and its implementation in practice are still not clear; varying definitions exist. • Students should become STEM literate. • STEM is applied across discipline-specific contexts. • STEM integrates subjects together, particularly technology/engineering within science and mathematics. • STEM education is not limited to careers in STEM fields; it is useful for all fields. • STEM is about creating “innovators” and problem solvers. • STEM is about applying academic concepts in real world • STEM is about applying across school, community, work, and global enterprise to be competitive.
STEM Education Coalition	http://www.stemedcoalition.org/wp-content/uploads/2010/05/BLS-STEM-Jobs-report-spring-2014.pdf	The STEM Education Coalition is a political advocacy group that informs federal and state policymakers about the importance of STEM education.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other competencies included: • STEM is interdisciplinary: “STEM fields are closely related and build on each other. For example, math provides the foundation for physics—and physics, in turn, for engineering. Engineers can apply their knowledge of physics to make high-tech devices that are useful for testing theories in physics. Advances in physics may then lead to advances in engineering and technology” (p. 1).

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
STEMx	http://www.stemx.us/2014/03/the-idea-of-integrated-stem/	STEMx is a network of state STEM education initiatives to improve policy and teaching practice. Currently, STEMx includes 20 states and Washington, D.C.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other competencies included: • Integrated STEM—"a transdisciplinary approach which may include problem-based learning, design projects, and other experiential methods." • Strategies that Engage Minds®—"coined by the North Carolina Science, Mathematics, and Technology Education Center to reflect the hands-on, active involvement in STEM education that promotes essential cognitive skills for the 21st century." ▪ Other notes: • The linked article specifically talks about different definitions of STEM. They focus on explaining the idea of "integrated STEM."
International Technology Education Association (ITEA)	https://www.iteea.org/File.aspx?id=67767&v=691d2353	ITEA is a professional organization that promotes technological literacy by supporting the K–12 teaching of technology and engineering.	▪ STEM is not explicitly mentioned in the ITEA standards. ▪ Academic disciplines included: • The nature of technology • Technology and society • Design • Abilities for a technological world • The designed world ▪ Other notes: • "Provide opportunities for students to make connections among a variety of technologies, thereby helping them develop a common core of technological learning. The resources should also allow for the integration of other fields of study into technological studies" (p. 29). • "Include experiences and activities that enhance and promote hands-on learning, including problem-based and design-based learning. These experiences and activities also should be open-ended, requiring students to develop and use technological thinking and challenging them to use and apply it in a variety of settings" (p. 29).

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
The International Society for Technology in Education (ISTE)	http://www.iste.org/standards/iste-standards/standards-for-students	ISTE is a nonprofit organization serving educators committed to connecting learners to a connected world.	▪ STEM is not explicitly mentioned in the ISTE standards. ▪ Academic disciplines included: • Creativity and innovation • Communication and collaboration • Research and information fluency • Critical thinking, problem solving, and decision making • Digital citizenship • Technology operations and concepts ▪ Other notes: • "The ISTE Standards describe the skills and knowledge students need to learn effectively and live productively in an increasingly global and digital society." (Found under ISTE Standards website.)

Source	Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
SkillsUSA	http://www.skillsusa.org/about/skillsusa-framework/	SkillsUSA is an organization that strives to improve the quality of America's skilled workforce through a structured program of citizenship, leadership, employability, technical, and professional skills training.	▪ Academic disciplines included: • Computer and technology literacy • Job-specific skills • Safety and health • Service orientation • Professional development ▪ Other competencies: • Integrity • Work ethic • Professionalism • Responsibility • Adaptability/flexibility • Self-motivation • Communication • Decision making • Teamwork • Multicultural sensitivity and awareness • Planning, organizing, and managing • Leadership ▪ STEM definition: • "The magic of CTE is the definition of STEM not just Science or Technology, Engineering or Math but the integration of two or more of these topics in the context that students are passionate about. Without the combination of two or more of the STEM components, you are not teaching STEM." (Found under STEM and CTE Alignment website.) ▪ Other notes: • "Often times when individuals think about STEM, they think of scientists and engineers which is right on target. However, what doesn't come to mind are the numerous high wage, high skilled, high demand careers that for which CTE is preparing students." (Found under STEM and CTE Alignment website)

Table A2. State Agency/Organization STEM Website Scans

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Indiana STEM Resource Network (I-STEM)	https://www.istemnetwork.org/wp-content/uploads/2014/12/I-STEM-Summary-9-2015.pdf	I-STEM works to improve STEM education through partnerships, standards alignment, policy recommendations, professional development, and assessment. In particular, I-STEM focuses on K–8 STEM education.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other competencies included: • Critical thinking • Problem-solving skills ▪ Other: "I-STEM supports K–12 teachers and education leaders working to implement high academic standards towards STEM literacy for all students."
Iowa Governor's STEM Advisory Council	http://www.iowastem.gov/about	The Iowa Governor's STEM Advisory Council consists of leaders in higher education, business leaders, PK–12 educators, and state and government officials.	▪ Academic disciplines included: • Science: The study of the nature of the universe • Technology: The application of information to the design of goods and services • Engineering: The application of knowledge for the benefit of humanity • Mathematics: The universal language of nature ▪ Other: The STEM Council uses the following definition of STEM: • An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, Kohler, & Hallinen, 2009).

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Kansas City STEM Alliance	http://www.kcstem.org/about/ http://www.kcstem.org/resources/students/	The Kansas City STEM Alliance brings together educators, industry professionals, and government leaders to support K–12 STEM education.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other: • The alliance's main goal is to promote STEM readiness for the workforce. • On the students' page, the alliance lists several benefits of STEM education, including the following: unique classroom experiences, extracurricular programs, field experience with STEM professionals, and preparation for higher education and careers.
Michigan STEM Partnership	http://mistempartnership.com/	The Michigan STEM Partnership consists of educators, professionals, and policymakers who are interested in improving STEM education.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other competencies included: • Cross-disciplinary education • Project-based, applied learning • Connections to real-world activities

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Minnesota Department of Education	▪ Academic disciplines: http://scimathmn.org/about/ ▪ Other competencies: • http://scimathmn.org/stemtc/resources/mathematics-best-practices • http://scimathmn.org/stemtc/resources/science-best-practices	SciMathMN is a nonprofit organization that partners education and business leaders to promote K–12 STEM education in Minnesota. It created the official mathematics and science curriculum frameworks for the Minnesota Department of Education in 2011.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other: • SciMathMN also includes best practice guidelines for teachers in mathematics and science. • Mathematics: modeling word problems, maintaining high expectations, questioning, choosing mathematical tasks, and representing mathematical ideas. • Science: science for all (inclusion), professional development for science, instructional technology, engineering design, inquiry, literacy in science, science in informal settings, science safety, cultural connections, how students learn science, STEM integration, societal connections, environmental science, curriculum development, and lesson design.

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Missouri Department of Elementary and Secondary Education (DESE)	https://dese.mo.gov/sites/default/files/te_program_planning_handbook_1.pdf	DESE oversees the state's K–12 education.	▪ Academic disciplines included (under the Division of Career Education, Technology, and Engineering): • Architecture and construction • Arts, audiovisual technology, and communications • Manufacturing • Science, technology, engineering, and mathematics • Transportation, distribution, and logistics ▪ Other competencies included: • According to the Standards for Technological Literacy: Content for the Study of Technology (STL), technological design is a distinctive process that has a number of defining characteristics. Design is a process that has a defined purpose with identifiable requirements (constraints) and follows a systematic approach allowing for iteration. The design process encourages human creativity utilizing intuition, feelings, and impressions leading to the designer's "best possible solution." • Technological literacy: "The ability to use, manage, assess, and understand technology. A technologically literate person understands (in increasingly sophisticated ways that evolve over time) what technology is, how it is created, and how it shapes society, and in turn is shaped by society (ITEA, 2000, p. 9)" (p. 5). ▪ Other: The PDF also includes a section on the philosophy of technology and engineering (starting on p. 5). This section discusses the importance of technological education and the societal context for STEM.

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Mississippi Department of Education	▪ http://www.mde.k12.ms.us/OCTE/PA ▪ http://www.mde.k12.ms.us/MBE/manual/policy-8200-vocational-general-administration-(career-and-technical-education)/policy-8213-new-program-approval-for-career-and-technical-education-ongoing-programs		▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics • Energy technology • Polymer science ▪ Other notes: • In Mississippi, all ninth graders take a STEM class, which "enables students to explore technology resources, processes, and systems that lead to enhanced career development and advanced education."
Nebraska Career Education	http://www.education.ne.gov/nce/documents/ataglance/stem.pdf	Nebraska Career Education (NCE) is a division of the Nebraska Department of Education, which oversees career and technical education courses.	▪ Academic disciplines included: • Science and math • Engineering and technology ▪ Other competencies included: • Quantitative problem-solving • Engineering design • Real-world application ▪ Other notes: In NCE's organization, STEM is part of a larger group called skilled and technical services (STS). STS also includes manufacturing, architecture and construction, and transportation, distribution, and logistics.

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Nebraska Children & Families Foundation/ Beyond School Bells	http://www.nebraskachildren.org/what-we-do/beyond-school-bells.html	The Nebraska Children & Families Foundation (Nebraska Children) is a nonprofit that supports the education and well-being of youth. Nebraska Children is part of Beyond School Bells, which is a statewide partnership to promote expanded learning opportunities, including those for STEM.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other competencies included: • Problem-solving • Critical thinking ▪ Other notes: • High-quality STEM ELO programs produce positive outcomes: • Improved attitudes toward STEM fields and careers. • Increased STEM capacities and skills. • Higher likelihood of graduation and pursuing a STEM career.
North Dakota Department of Public Instruction	https://www.nd.gov/dpi/SchoolStaff/FTP/STEAM/	The North Dakota Department of Public Instruction (DPI) oversees the state's K–12 education. The link leads to the March/April issue of DPI's STEAM newsletter.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics • The arts • "Integrative methodology"—teaching STEM or STEAM disciplines together and solidifying connections rather than isolating each subject ▪ Other notes: • A comprehensive definition is as follows: "Integrative STEM education refers to technological/engineering design-based learning approaches that intentionally integrate the concepts and practices of science and/or mathematics education with the concepts and practices of technology and/or engineering education. Integrative STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc." (p. 2).

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
South Dakota STEM Working Group	http://doe.sd.gov/contentstandards/documents/STEWkgpOv.pdf	In June 2015, a working group met to develop new South Dakota state standards for STEM. This group included Department of Education staff, consultants, postsecondary thought partners, and high school STEM teachers.	▪ Academic disciplines included (pp. 1, 4): • Science • Technology • Engineering • Mathematics • Aviation • Computer science • Robotics • Energy ▪ Other competencies included (pp. 2, 4): • Interdisciplinary work • Communications • Teamwork • Troubleshooting and problem-solving • Self-motivation • Multi-tasking • Time management • Ethics • Responsibility • Real-world context ▪ Other notes: • In South Dakota, STEM is considered a cluster under career and technical education (CTE).
Utah STEM Action Center	http://stem.utah.gov/about-stem/	The Utah STEM Action Center promotes K–12 STEM education and alignment with higher education STEM programs.	▪ Academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Other notes: • The Action Center's mission statement: "The STEM Action Center is Utah's leader in promoting science, technology, engineering, and math through best practices in education to ensure connection with industry and Utah's long-term economic prosperity."

Source Title/Citation	Link Webpages	Description of the Source	Definition of Science, Technology, Engineering, and Mathematics
Wisconsin Department of Public Instruction	STEM Overview: http://dpi.wi.gov/stem Technology and Engineering Standards: http://dpi.wi.gov/sites/default/files/imce/cte/pdf/te_standards.pdf	The Wisconsin Department of Public Instruction (DPI) oversees the state's K–12 education.	▪ Overall academic disciplines included: • Science • Technology • Engineering • Mathematics ▪ Technology and engineering standards content areas include: • Agriculture, food, and natural resources • Business and information technology • Family and consumer sciences • Health sciences • Marketing, management, and entrepreneurship • Technology and engineering ▪ Other notes: • "Authentic STEM education offers students an opportunity to engage with meaningful problems beyond the application of isolated pieces of science, technology, engineering, and mathematics learning." • "STEM education is more than the sum of its parts, functioning as a metadiscipline that provides a way of approaching problems across contexts. In the 21st century, major societal problems do not belong to any one discipline; they must be solved through multiple approaches and perspectives." • "Wisconsin, and the United States generally, need more graduates who are STEM literate—prepared for the realities of today's workforce." • "Technology and engineering education is an interdisciplinary STEM subject that provides multifaceted opportunities for students to become prepared for careers and for postsecondary education through theory and hands-on lessons in the classroom and industry-based opportunities outside of schools" (p. 7). • "STEM teaching and learning is another innovative approach for all learners that will contribute to Wisconsin being globally competitive" (p. 26). • "Technology and engineering education is at the heart of today's high-skilled, high-tech global economy. Many of workforce conversations involve manufacturing, construction, communications, transportation and STEM and easily relate to the content of technology and engineering classes are at the forefront of today's workforce and economic issues" (p. 26).

Table A3. STEM Definitions and Trends Among State-Affiliated STEM Organizations

State-Group Name	Organizational Affiliation				Defining Characteristics			Purpose	
	K–12	**CTE K–12**	**Industry**	**Higher Ed**	**Science, Engineering, Technology, and Math**	**Other STEM Disciplines or Competencies STEM as Pedagogy**	**STEM as Integrated or Interdisciplinary**	**Pipeline to STEM Careers**	**STEM Literacy for All**
Iowa Governor's STEM Advisory Council	X			X	X		X "…an interdisciplinary approach to learning…"	X	X STEM literacy
Indiana STEM Resource Network	X (K–8)		X		X	X Critical thinking Problem-solving skills	"I-STEM"	X	X STEM literacy
Kansas City STEM Alliance	X		X		X			X "Readiness for the workforce"	
Michigan STEM Partnership	X		X		X	X Project-based learning Connections to real-world activities	X "Cross-disciplinary education"	X	
Minnesota Department of Education	X		X		X		STEM integration and societal connections	X	

State-Group Name	Organizational Affiliation				Defining Characteristics			Purpose	
	K–12	CTE K–12	Industry	Higher Ed	Science, Engineering, Technology, and Math	Other STEM Disciplines or Competencies STEM as Pedagogy	STEM as Integrated or Interdisciplinary	Pipeline to STEM Careers	STEM Literacy for All
Missouri Department of Elementary and Secondary Education		X			X	X Human creativity, intuition, feelings, and impressions "leading to the designer's best possible solution." "Design is a distinctive process…follows a systematic approach allowing for iteration."		X	X Technological literacy
Mississippi Department of Education		X			X	X Energy technology Polymer science		X	
Nebraska Career Education		X			X	X Quantitative problem solving; engineering design, real-world application		X	
Nebraska Children & Families Foundation/Beyond School Bells	X				X	X Problem solving Critical thinking		X "Higher likelihood of pursuing STEM careers"	X
North Dakota Department of Public Instruction	X				X	X The arts (part of STEAM)	X "Integrative STEM education"	X	

State-Group Name	Organizational Affiliation				Defining Characteristics			Purpose	
	K–12	**CTE K–12**	**Industry**	**Higher Ed**	**Science, Engineering, Technology, and Math**	**Other STEM Disciplines or Competencies STEM as Pedagogy**	**STEM as Integrated or Interdisciplinary**	**Pipeline to STEM Careers**	**STEM Literacy for All**
South Dakota STEM Working Group		X			X	X Aviation Computer science Robotics Energy Teamwork; troubleshooting and problem solving; communications; self-motivation; time management; ethics, responsibility; real-world context	X "Interdisciplinary work"	X	
Utah STEM Action Center	X		X		X			X "Ensure connection with industry and Utah's long-term economic prosperity"	

State-Group Name	Organizational Affiliation				Defining Characteristics			Purpose	
	K–12	**CTE K–12**	**Industry**	**Higher Ed**	**Science, Engineering, Technology, and Math**	**Other STEM Disciplines or Competencies STEM as Pedagogy**	**STEM as Integrated or Interdisciplinary**	**Pipeline to STEM Careers**	**STEM Literacy for All**
Wisconsin Department of Public Instruction	X				X	Agriculture; business; family and consumer sciences; health sciences; marketing; technology and engineering “Hands-on lessons” a “way of approaching problems across contexts”	X “Metadiscipline”	X	X STEM literate

Appendix B. Key Informants

Key informant interviews were conducted with seven individuals, including members of the Midwest STEM network, industry representatives, and other leaders from within the STEM education community. Table B1 includes the names, titles, and affiliations for key informants.

Table B1. List of Key Informants With Affiliations

Informant Name	Role	Affiliation
Dr. Jeff Weld	Executive Director	Iowa Governor's STEM Advisory Council
Kim Wetzel	Foundation Director Consultant	Bemis Company Foundation
Steven Triplett	Program Director of STEM Partnerships	ACT
Dr. Michael Lach	Director of STEM Education and Strategic Initiatives	University of Chicago
Jeremy Eltz	Assistant Director of College and Career Readiness	Indiana Department of Education
Jillian Steffek	Senior Principal Engineer of Materials and Process Engineering	Oshkosh Corporation
Cathy Stagmer	Global Community Relations Manager	Joy Global

Appendix C. List of Sources

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